A Preliminary Analysis of Haft Variability in South Carolina Kirk Points

Andrew A. White

Introduction

The Kirk Corner-Notched cluster, as defined by Justice (1987:71-82), contains a variety of technologically and stylistically similar point forms dating to the Early Archaic period of the Eastern Woodlands. Generally, these points have trianguloid blades with haft regions formed by corner-notching (see Justice 1987; Stafford and Cantin 2009). Ground basal edges, blade serration, and alternate beveling of the blade occur in varying frequency. Named varieties such as Kirk Corner-Notched, Stilwell, Palmer, Charleston, Decatur, and Pine Tree are generally distinguished from one another based on criteria related to haft and blade morphology, basal finishing techniques, and blade resharpening (see discussions in Brookes 1985; Cable 1996; DeRegnaucourt 1992; Justice 1987; Nolan and Fishel 2009; Stafford and Cantin 2009). For the purposes of this paper, the simple term "Kirk" will be applied to all the varieties in this larger family of point forms.

Kirk points are geographically widespread, occurring across an immense area extending north-south from the southern Great Lakes to the Florida Peninsula and east-west from the Mississippi Corridor to the Atlantic Coast. While there is certainly enough similarity in these points across their wide geographic distribution to recognize general inter-relationships (e.g., Ellis et al. 1998:162), there is also significant variability in size, shape, and attributes related to patterns of use and rejuvenation. Radiocarbon dates indicate that the Kirk phenomenon is focused in the period ca. 9500-8800 radiocarbon years before present (RCYBP) (see Cantin 2000; Chapman 1976; Nolan and Fishel 2009; Stafford and Cantin 2009). The widespread occurrence of Kirk points during that period is often referred to as the "Kirk Horizon" (see Tuck 1974; see also Coe 1964:122).

The emergence of the Kirk Horizon remains unexplained, and what it actually represents remains largely unexplored. Relationships among the different varieties of Kirk points and between Kirk and the varieties of side-notched points that appear to immediately pre-date Kirk (e.g., Big Sandy/Taylor/Bolen in the Southeast and Thebes cluster points in the Midcontinent) are not well understood. Even in areas with stratified sequences, the "ancestor-descendent" relationships between various Early Archaic point technologies are not clear. Tuck (1974:77), for example, identifies Big Sandy as the ancestor of Kirk (see also Stothers et al. 2001), while other researchers have speculated on links between Thebes and Kirk (e.g., Kimball 1996:158), and Dalton and Kirk (Cantin 2000:100). Brookes (1985) places Decatur points outside the Kirk cluster altogether and recognizes a Plains affinity for Lost Lake, which some researchers group with Kirk and others (e.g., Justice 1987:58-59) place within the Thebes cluster. While Kirk is clearly a pan-eastern phenomenon, regional chronologies and technological relationships appear inconsistent and are not easy to reconcile.

The characteristics of Kirk societies, likewise, remain poorly understood. Generally, Early Archaic societies are thought to have been organized into small, highly mobile bands that practiced a forest foraging economy. It is apparent that Kirk points were often lost/discarded across the interior of the Eastern Woodlands in a wide variety of topographic settings, suggesting these groups were making regular use of almost all parts of the landscape (e.g., Cantin 2000; Munson 1986; Stafford 1994). The transport distances of lithic raw materials in the Midcontinent are consistent with the idea that Kirk groups were making annual movements of several hundred kilometers (Adovasio and Carr 2009; Cantin 2000; White 2014). Scales of mobility may have been somewhat smaller in the Southeast (Ellis et al. 1998:162), but lithic raw materials were still being transported significant distances through mechanisms of mobility and/or exchange (Anderson and Hanson 1988:280; Meredith 2011). Various models of Kirk mobility and subsistence have been proposed for the Carolinas (e.g., Anderson and Hanson 1988; Daniel 2001; Gillam 2015). Increases in population during the Early Archaic period are inferred from increases in the number of sites, as well as lost/discarded hafted bifaces dating to the Early Archaic period relative to the Paleoindian period.

Because Kirk sites with intact cultural deposits are so rare, the points themselves are one of our main sources of information about these Early Archaic groups. Understanding variability in Kirk points is key to unlocking the potential of these points to tell us something about how those societies were structured and what mechanisms were used to knit those highly mobile, highly dispersed groups into an apparently continuous social fabric that extended across such an immense and diverse geographic area. Different facets of variability in projectile points are potentially linked to different aspects of how the tools were created and used, however, and were potentially sensitive to everything from the way a tool was designed to do a specific task to the multi-level social networks that structured human interaction and social learning. Because of this, careful analysis of variability in Kirk points is an important step toward using information about variability to address larger questions about the societies that produced them and the behaviors of the people, families, and groups that comprised those societies.

In this paper, I present a preliminary analysis of haft variation focused on a sample (n = 46 total) of Kirk points from the Larry Strong Collection (n = 41) and the Nipper Creek cache (n = 5) from Allendale and Richland counties, respectively. The assemblage from the Larry Strong Collection contains points made from a single raw material (Coastal Plain chert) and found in the same area (Allendale County), allowing us to hold those two variables constant. Given the large size of the Larry Strong Collection, it is a "long time" assemblage that certainly contains Kirk points from the full range of time those points were produced in the region. The Nipper Creek cache, in contrast, is a "short time" assemblage that was produced during a small window of time. Comparison of these assemblages can be used to explore which aspects of haft morphology may be carrying useful stylistic information that is sensitive to change through time and, potentially, patterned in ways that can eventually tell us something meaningful about Kirk societies.

Potential Sources of Variability

Style and function can be regarded as "the fundamental sources of variability in archaeological materials" (Meltzer 1981:313). *Functional variability* is defined here as formal variability related to the operation of an artifact in the material realm: it is what an artifact does and is designed to do (Kamminga 1982; Sackett 1982). Variability created by use during the life of a stone tool (e.g., changes in form caused by resharpening and/or repair) can be considered functional.

Following Sackett (1982), *stylistic variability* is defined here as that portion of formal variability that is not functional in the material realm: function and style together can be assumed to exhaust the majority of formal variability. Less constrained by functional considerations, stylistic choices are free to vary and are sensitive to patterns of social learning and social interaction. Sackett (1985, 1986, 1990) argued that much of what we perceive as "style" occurs because the choices artisans make among the range of options potentially available to them tend to be quite specific and consistent, and that these are dictated largely by the craft traditions within which the artisans have been enculturated as members of social groups (Sackett 1985:157).

The qualities of the raw materials that were utilized to craft points is also a potential source of variability (not all raw materials were available in the sizes necessary to create large points, for example, and the knapping characteristics of lithic raw materials vary widely), as is copying error that is intrinsic to hand-crafted material culture (e.g., see Eerkens 2000; Eerkens and Lipo 2005).

All of these potential sources of variability – function, style, raw material constraints, and copying error – are blended into the crafting of a stone tool. Not all are equally useful for addressing questions about prehistoric societies, however. The parsing out of stylistic variability in Kirk points is important because it is that component of variability that (in conjunction with other forms of analysis) has the potential to tell us the most about Kirk societies. Understanding the patterning of stylistic variability through time and across space is the component of the archaeological data needed to explain the emergence of the Kirk Horizon and address questions about the characteristics of Kirk societies.

Partitioning stylistic and functional variability generally involves isolating functional variability and then assuming that the remaining variability is non-functional (i.e, stylistic). I have argued elsewhere (White 2012, 2013) that variability related to haft dimensions (e.g., haft width and thickness) is essentially functional in that it is closely constrained by the dimensions of the shaft in which the point was hafted. Variability related to subtle differences in features such as basal edge shape and notch morphology, however, is likely to be much less constrained by basic functional considerations. Such aspects of shape can be regarded as potentially good carriers of stylistic information.

Sample

The sample considered in this paper comprises 46 Kirk points, summarized in Table 1. The majority (n = 41) are from the Larry Strong Collection; the remainder (n = 5) are from the Nipper Creek cache.

The Larry Strong Collection was collected by Dr. Larry Strong, a mathematics professor at the University of South Carolina Salkehatchie campus, over the course of four decades from the surfaces of numerous sites in Allendale County, South Carolina. Strong donated an estimated 17,000 artifacts from his collection to the South Carolina Institute of Archaeology and Anthropology in the 1990s. Inventorying of that collection is ongoing, supported by a grant from the Archaeological Research Trust (White 2016). Approximately 450 of the points inventoried so far fall within the Kirk Corner-Notched cluster as defined by Justice (1987:71-81). From that assemblage, points were chosen for this analysis based on the presence of an intact haft region that did not appear to have been extensively modified from its original form. Analysis of the Kirk points in the Larry Strong Collection is ongoing.

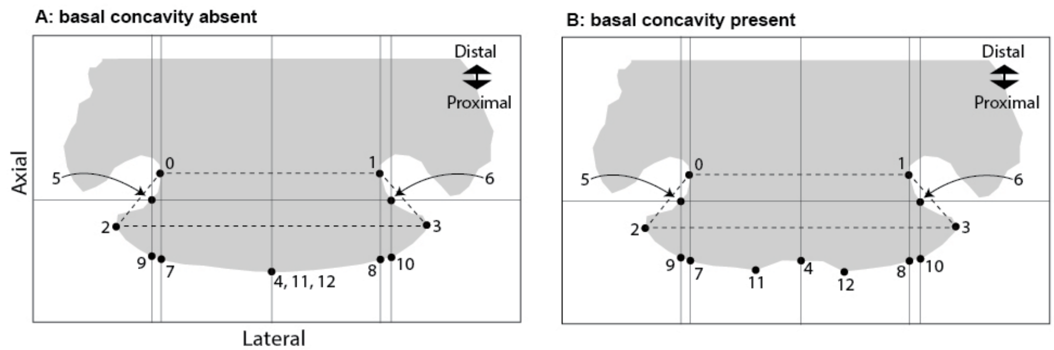
The Nipper Creek Cache is comprised of six Kirk points that were exposed during a 1986 archaeological field school at the Nipper Creek site (38RD18) in Richland County, South Carolina. According to

Table 1. Summary of sample used in analysis. CPC: Coastal Plains Chert; LHB: left-hand bevel (beveled edge is on the left side of the point when the point is held with the tip up); LHT: left-hand twist (the blade is resharpened on alternate edges but there is no distinct line separating the resharpened portion from the rest of the blade face).

ID No.	Collection	Inventory No.	County	Raw Material	Neck Width (mm)	Maximum Thickness (mm)	Basal Grinding	Beveling
5927	Larry Strong	LS-1	Allendale, SC	CPC	17.03	7.9	Present	Absent
5928	Larry Strong	LS-2	Allendale, SC	CPC	15.51	8.3	Present	Absent
5929	Larry Strong	LS-3	Allendale, SC	CPC	20.77	9.2	Present	Absent
5930	Larry Strong	LS-4	Allendale, SC	CPC	19.12	8.4	Present	Absent
5931	Larry Strong	LS-5	Allendale, SC	CPC	17.66	6.9	Present	Absent
5933	Larry Strong	LS-7	Allendale, SC	CPC	15.8	6.8	Present	Absent
5935	Larry Strong	LS-9	Allendale, SC	CPC	14.07	7.9	Present	Absent
5937	Larry Strong	LS-11	Allendale, SC	CPC	17.14	9.1	Present	Absent
5938	Larry Strong	LS-12	Allendale, SC	CPC	15.58	10.9	Present	Absent
5940	Larry Strong	LS-14	Allendale, SC	CPC	17.19	8.8	Present	LHB
5941	Larry Strong	LS-15	Allendale, SC	CPC	22.61	6.5	Present	Absent
5942	Larry Strong	LS-16	Allendale, SC	CPC	12.23	5.1	Absent	LHB
5945	Larry Strong	LS-19	Allendale, SC	CPC	16.38	8.1	Present	Absent
5946	Larry Strong	LS-20	Allendale, SC	CPC	20.54	7.5	Present	Absent
5947	Larry Strong	LS-21	Allendale, SC	CPC	17.05	7.6	Present	LHB
5948	Larry Strong	LS-22	Allendale, SC	CPC	16.13	7.2	Present	Absent
5949	Larry Strong	LS-23	Allendale, SC	CPC	16.96	7.7	Present	LHB
5950	Larry Strong	LS-24	Allendale, SC	CPC	16.48	8.1	Present	Absent
5951	Larry Strong	LS-25	Allendale, SC	CPC	17.08	7.8	Present	Absent
5952	Larry Strong	LS-26	Allendale, SC	CPC	15.29	7.9	Present	Absent
5953	Larry Strong	LS-27	Allendale, SC	CPC	18.09	8.8	Present	LHT
5955	Larry Strong	LS-29	Allendale, SC	CPC	13.61	9.2	Present	Absent
5958	Larry Strong	LS-32	Allendale, SC	CPC	20.51	8.4	Present	Absent
5960	Larry Strong	LS-34	Allendale, SC	CPC	15.24	7.4	Present	LHB
5961	Larry Strong	LS-35	Allendale, SC	CPC	14.11	7.9	Present	Absent
5962	Larry Strong	LS-36	Allendale, SC	CPC	15.03	6.3	Present	LHB
5978	Larry Strong	LS-37	Allendale, SC	CPC	20.01	6.9	Present	Absent
5980	Larry Strong	LS-39	Allendale, SC	CPC	19.29	8.8	Present	Absent
5981	Larry Strong	LS-40	Allendale, SC	CPC	25.32	8.7	Present	Absent
5982	Larry Strong	LS-41	Allendale, SC	CPC	13.9	6.0	Present	LHB
5983	Larry Strong	LS-42	Allendale, SC	CPC	14.74	5.6	Present	LHB
5984	Larry Strong	LS-43	Allendale, SC	CPC	16.46	6.6	Present	Absent
5985	Larry Strong	LS-44	Allendale, SC	CPC	14.45	7.1	Absent	LHB
5986	Larry Strong	LS-45	Allendale, SC	CPC	13.36	6.0	Absent	LHB
5987	Larry Strong	LS-46	Allendale, SC	CPC	18.39	7.8	Present	Absent
5988	Larry Strong	LS-47	Allendale, SC	CPC	17.77	5.9	Absent	LHB
5989	Larry Strong	LS-48	Allendale, SC	CPC	12.62	5.6	Present	Absent
5990	Larry Strong	LS-49	Allendale, SC	CPC	17.42	7.1	Present	LHB
5991	Larry Strong	LS-50	Allendale, SC	CPC	13.77	6.1	Present	Absent
5993	Larry Strong	LS-52	Allendale, SC	CPC	17.58	7.1	Present	LHB
5998	Larry Strong	LS-57	Allendale, SC	CPC	15.31	-	Present	Absent
5963	Nipper Creek	NC-4 (D)	Richland, SC	Rhyolite	15.42	6.0	Present	Absent
5964	Nipper Creek	NC-5 (E)	Richland, SC	Ridge and Valley	18.48	8.1	Present	Absent
5965	Nipper Creek	NC-3 (C)	Richland, SC	Rhyolite	18.89	6.9	Present	Absent
5966	Nipper Creek	NC-2 (B)	Richland, SC	Rhyolite	16.71	7.4	Present	Absent
5968	Nipper Creek	NC-6 (F)	Richland, SC	Rhyolite	17.53	7.2	Present	Absent

Goodyear et al. (2004), the six points were found within a small horizontal area (about 264 cm^2) and within about 5-10 cm vertically. It is likely that the points were originally placed in a pit (no outline of a pit was discerned) or on a common surface. One of the points (Figure 1A as shown by Goodyear et al. 2004) has a fractured ear and was excluded from the study.

The points from the Larry Strong Collection are made from Coastal Plain chert, a Tertiary marine chert that outcrops in western South Carolina and central Georgia (Bridgman Sweeney 2013:Figure 3-5; Goodyear 2014; Goodyear and Charles 1984). The most likely source of the raw material used to make the points in the Larry Strong Collection is the vicinity of Allendale County itself, which contains outcrops of Coastal Plain chert known locally as "Allendale" and "Brier Creek" (Goodyear and Charles 1984). Five of the points from the Nipper Creek cache were made from metavolcanic rhyolite (typical of the Uwharrie Mountains of North Carolina), and the remaining point was made from Ridge and Valley chert from eastern Tennessee (Goodyear et al. 2004).



Landmarks 0 & 1: landmarks defining minimum width of haft region distal to basal edge

Landmarks 2 & 3: landmarks at locations of maximum width of haft distal to basal edge but proximal to Landmarks 0 and 1

Axial Plane: flat plane with corners defined by Landmarks 0, 1, 2, and 3 (indicated with dashed line on the diagram)

Landmark 4: landmark at location where axial line bisecting the Axial Plane intersects the basal edge of the haft

Landmarks 5 & 6: landmarks where lateral line bisecting the Axial Plane intersects the lateral edges of the haft

Landmark 7: landmark at location where axial line through Landmark 0 intersects the basal edge of the haft

Landmark 8: landmark at location where axial line through Landmark 1 intersects the basal edge of the haft

Landmark 9: landmark at location where axial line through Landmark 5 intersects the basal edge of the haft

Landmark 10: landmark at location where axial line through Landmark 6 intersects the basal edge of the haft

Landmarks 11 & 12: landmarks at locations of maximum proximal deviation of basal edge; on a point with no basal concavity (as shown in diagram A), these landmarks will be at the same location as the location of maximum convexity (typically near the center of the basal edge); on a point with a basal concavity, these landmarks will be on either side of the concavity as shown in diagram B

Figure 1. Definition of the landmarks used in morphometric analysis.

Methods

Although the morphometric data used in this analysis are two-dimensional, they were obtained from three-dimensional models produced using a laser scanner. This section describes the hardware, software, settings, and processing and mathematical procedures used to produce the models and extract data from them.

A NextEngine Desktop 3D scanner (UltraHD, Model 2020i with autodrive) was used to collect data for the production of 3D models. Each point was scanned in two orientations to collect data from the edges and faces of the point. For each orientation, the point was automatically rotated through 10 divisions. Data were collected at the middle HD setting (67k points/square inch).

Scan data were processed in ScanStudio software (version 2.0.2). The edge and face scans were trimmed to remove extraneous features (such as the arm holding the point). The edge and face scans were aligned and fused into a single model. Fused models were trimmed to remove artifacts left by the fusing process and then remeshed to smooth the surfaces and fill any holes. Finally, each model was simplified and then exported into file formats for analysis (.PLY) and online distribution (.STL).

Landmark software (version 3.0) was used to place a series of 13 landmarks on each of the 3D models. Definitions of the landmarks are provided in Figure 1. The first step in placing the landmarks was to orient the model to minimize the neck width (the lateral distance between the notches) and maximize the symmetry of the basal edge. This step has the potential to be slightly subjective. The first four landmarks are placed to mark the location of greatest constriction of the neck (Landmarks 0 and 1) and widest flare of the haft (Landmarks 2 and 3). Those four landmarks are then used to establish the corners of the axial plane. Landmarks 4-10 are placed with reference to the axial plane as described in Figure 1. The remaining two landmarks (11 and 12) are placed at the locations of the maximum proximal deviation of the basal edge. If there is a central basal concavity, these landmarks are positioned on either side of the concavity. If the basal edge is convex, both landmarks are placed at the single location of the greatest proximal deviation. Note that the defined landmarks are all located along the edges of the haft and essentially describe a two-dimensional shape.

Data were exported as a text file containing the xyz coordinates of all 13 landmarks placed on each model. These data were manually edited to produce a text file that could be imported into the program MorphoJ (version 1.06d).

MorphoJ was used to perform a full Procrustes fit on the three-dimensional coordinate data. Procrustes analysis is a mathematical procedure that uses the locations of corresponding points to scale, align, and rotate shapes, effectively filtering out size and allowing variation in shape to be independently analyzed (see Stegmann and Gomez 2002). The new (dimensionless) xyz coordinates produced by the Procrustes fit were exported and edited to remove the y coordinate, leaving the remaining two coordinates that described the two-dimensional shape of the haft as seen in plan view. Those coordinates were reimported into MorphoJ and a new Procrustes fit was performed on those two-dimensional data.

A principal components analysis (PCA) was performed on the results of the two-dimensional Procrustes fit, also using MorphoJ. PCA is a mathematical procedure that reduces the dimensionality of datasets with multiple variables. It uses analysis of covariance to first extract the axis which captures the greatest amount of variance in the data. This is called the first principal component. It then finds the axis orthogonal to the first axis which captures the greatest amount of variance (the second principal component). The process continues, which each succeeding component capturing less variance than the one that preceded it.

The linear distance between Landmarks 0 and 1 (i.e., "neck width") was measured digitally in Landmark. The maximum thickness of each point was measured using calipers. The maximum thickness measurement was taken at the point of maximum thickness along the proximal-distal axis, which was typically located distal to the neck of the point. This measurement was not taken if a point was broken or damaged in such a way as to make it unclear whether the thickest portion of the point was present.

Metric Data

Summary statistics for neck width and maximum thickness are shown in Table 2. The ranges, means, and standard deviations of these variables in the South Carolina sample are comparable to those of the much larger sample of Kirk points from the Midcontinent reported by White (2012, 2013). The two samples are the same in terms of mean neck width: both average 16.8 mm. The South Carolina sample is, on average, almost a millimeter thicker than the Midcontinental sample with higher minimum and maximum values. The difference in thickness between the South Carolina and the Midcontinental sample is statistically significant using a t-test to compare the means ($t = 6.0218$, $df = 639$, two-tailed $p < 0.001$).

The coefficient of variation (CV), calculated by dividing the standard deviation by the mean, is a simple statistic for expressing the amount of variability in an attribute relative to the value of the mean (Simpson and Roe 1939; Thomas 1986). This allows the relative amounts of variation to be compared among variables with different means.

As in the larger Midcontinental sample, the CV of both variables is less than 20 in the South Carolina sample. Previously (White 2012, 2013), I argued that these comparatively low coefficients of variation are likely because variability in hafting width and thickness is significantly constrained by the size and configuration of the hafts (shafts or foreshafts) in which a point will be mounted. In compound projectile weapons that are designed to perform a limited set of tasks, the sizes of the non-lithic parts of the weapon are similarly likely to be relatively standardized and may be highly curated, requiring more effort to produce than the points themselves (Keeley 1982). Neck width and maximum thickness are moderately correlated in the South Carolina sample ($r = 0.36$).

Table 2. Summary statistics for metric variables in the South Carolina sample described here and the Midcontinental sample described by White (2012).

		South Carolina sample	Midcontinental sample
Neck Width	*n*	46	628
	Minimum	12.2	9.7
	Maximum	25.3	27.1
	Mean	16.8	16.8
	Standard Deviation	2.61	3.04
	CV	15.5	18.1
Maximum Thickness	*n*	45	596
	Minimum	5.1	4.5
	Maximum	10.9	10.1
	Mean	7.5	6.6
	Standard Deviation	1.17	0.95
	CV	15.6	14.4

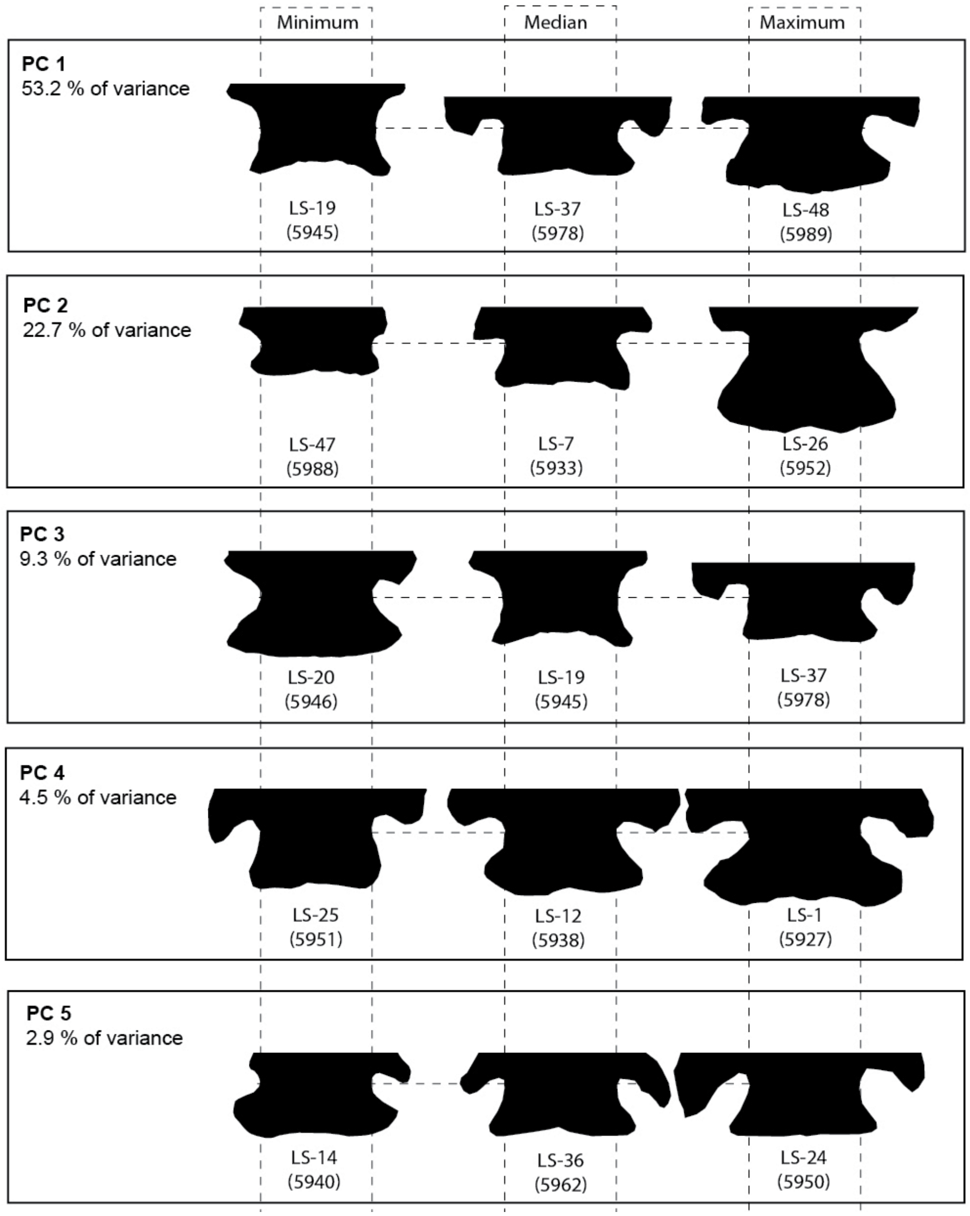


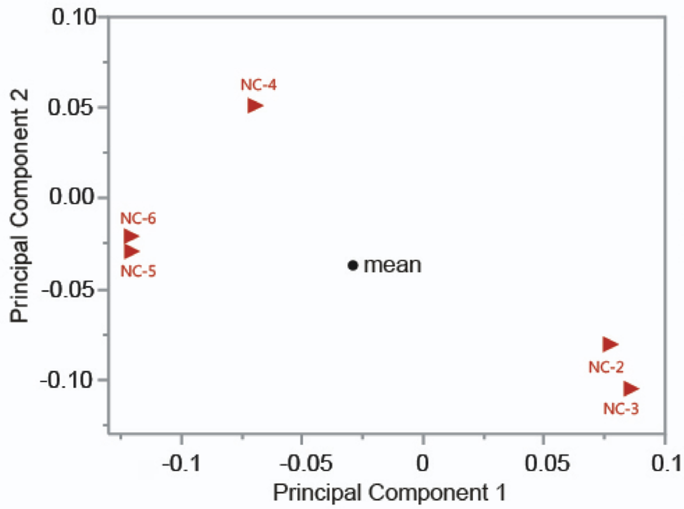
Figure 2. Basal shapes of points representing the minimum, median, and maximum values of principal components 1 through 5.

Principal Components of Shape

The principal components analysis of the two-dimensional Procrustes fit data returned results for 22 components, the first 5 of which captured over 92 % of the variability. This analysis will only consider the first five components.

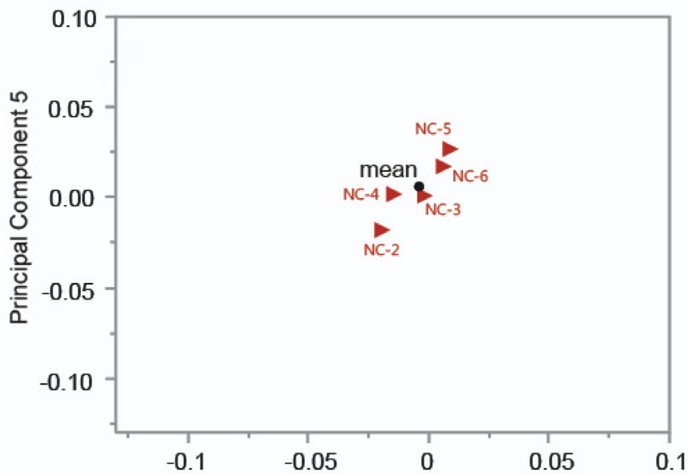
To try to understand what aspects of shape variability were captured by those components, the silhouettes of the hafts of points at the minimum, median, and maximum parts of the distribution of each of the principal components were compared (Figure 2). The silhouettes were scaled so that the minimum haft widths were approximately equal (vertical dashed lines) and placed to align the locations of the minimum haft width (horizontal dashed lines).

The first principal component accounts for over half of the variance in the sample. It appears to be most closely related to basal edge shape, specifically the presence and arrangement of incurvate and excurvate segments. While the points can be classified as having basal edges that are convex, concave, or straight, such a classification does not capture anywhere near the amount of variability in basal edge shape in the sample. Some convexities (such as on point LS-19 shown in Figure 2) span nearly the entire basal edge, while others (such on point LS-12 shown in Figure 2) are narrower concavities



Point	PC1	PC2	Distance from Mean
5963 NC 4	-0.0692	0.0512	0.0967
5964 NC 5	-0.1203	-0.0293	0.0914
5965 NC 3	0.0862	-0.1050	0.1340
5966 NC 2	0.0776	-0.0806	0.1154
5968 NC 6	-0.1205	-0.0209	0.0926
mean	-0.0292	-0.0369	0.1060

Mean dispersion = 0.1060



Point	PC4	PC5	Distance from Mean
5963 NC 4	-0.0143	0.0018	0.0111
5964 NC 5	0.0091	0.0268	0.0248
5965 NC 3	-0.0016	0.0010	0.0054
5966 NC 2	-0.0193	-0.0180	0.0283
5968 NC 6	0.0062	0.0172	0.0153
mean	-0.0040	0.0057	0.0170

Mean dispersion = 0.0170

Figure 3. Examples showing calculation of dispersion metric.

situated in the central portion of an otherwise convex basal edge. Concavities also vary in relative depth and in other aspects of their morphology.

Principal component 2, accounting for nearly a quarter of the variance, appears to be related to the proportions of the haft. Points with a relatively high ratio of haft width to haft length fall at one of the end of the spectrum, while points with a low ratio fall at the other.

Principal components 3, 4, and 5 appear to be capturing shape variation primarily associated with the lateral haft margins. The shape of the lateral haft edges is influenced by many things, including the angle, depth, width, and curvature of the notches, the roundedness of the basal ears, and the morphology of the articulation of the basal and lateral edges. Principal components 3 and 4 appear to be capturing the degree of haft flare (widening of the haft distal to the notches), while principal component 5 appears to be closely related to the distal-proximal location of the maximum haft width.

Inferring Sources of Variability

The sample of Kirk points incorporates a large amount of variability in shape. The Nipper Creek cache presents an opportunity to try to understand which dimensions of variability in the larger sample might be most sensitive to time. Because the Kirk points from the Larry Strong Collection (n=41) are made from a single raw material and were collected from a single county, the amount of variability attributable to differences in raw material and space is small in that portion of the sample: one would expect that a large proportion of the variability would be related to change through time and/or idiosyncratic variation. The points in the Nipper Creek cache (n=5), however, were presumably made during a very short period of time. This suggests temporal variability is likely to be minimal or absent. Variability in the Nipper Creek points would logically be attributable to some combination of space, raw material, and/or individual idiosyncrasies (there are two material types represented in the cache, and we cannot assume that all the points

Table 3. Summary of measures of variability of the principal components in the Nipper Creek and Larry Strong portions of the sample.

	PC 1	PC 2	PC 3	PC 4	PC 5
Nipper Creek ($n = 5$)	SD: 0.104 CV: 0.010 Range: 0.207	SD: 0.060 CV: 0.006 Range: 0.156	SD: 0.044 CV: 0.004 Range: 0.105	SD: 0.012 CV: 0.001 Range: 0.028	SD: 0.017 CV: 0.002 Range: 0.044
Larry Strong ($n = 41$)	SD: 0.088 CV: 0.009 Range: 0.385	SD: 0.057 CV: 0.006 Range: 0.238	SD: 0.037 CV: 0.004 Range:0.171	SD: 0.027 CV: 0.003 Range: 0.105	SD: 0.021 CV: 0.002 Range: 0.075

were made by the same individual).

Because the points in the Nipper Creek cache were presumably created over a much shorter period of time than those in the Larry Strong Collection, it is logical to expect that time-sensitive aspects of shape would be significantly less variable in the Nipper Creek points than in the Larry Strong Collection. Table 3 provides three measures of variability for each principal component: standard deviation, range, and coefficient of variation (note that the coefficients of variation were calculated after adding 10 to each individual principal component score to move the distribution into a positive number range). Only in principal component 4 is the Nipper Creek assemblage notably less variable than the Larry Strong Collection using both the standard deviation and coefficient of variation as measures of variability.

The absolute ranges of all the principal components are lower in the Nipper Creek assemblage than in the Larry Strong Collection, which is to be expected give the size difference in the assemblages. Calculating the ratio between the Nipper Creek and Larry Strong ranges shows that the *amount* of difference in the range varies from a high of about 66% to a low of about 27%. The ratio of the Nipper Creek range to the Larry Strong range is above 50% in principal components 1, 2, 3, and 5, suggesting that range of variability in the larger Larry Strong assemblage is less than twice that of the Nipper Creek assemblage in those measures of shape. In principal component 4, however, the range of variability in the Larry Strong Collection is almost four times that of the Nipper Creek assemblage.

Several simple indicators of variability suggest that principal component 4 is substantially less variable in the Nipper Creek assemblage than in the larger sample from the Larry Strong Collection. Principal component 4 seems to primarily capture the degree of flare of the lateral haft margins, an attribute that is fairly regular among the Nipper Creek points. The Nipper Creek points vary in their basal edge shape from slightly excurvate to straight to moderately concave, and also vary substantially in the morphology of the ears.

To investigate which *combination* of principal components might best reflect change through time, measures of the dispersion of the Nipper Creek and Larry Strong portions of the sample were calculated for each possible pairing of principal components. Assuming again that the points in the Nipper Creek assemblage represent manufacture during a much smaller window of time than those from the Larry Strong assemblage, one would expect that a plot that minimized the dispersion of the Nipper Creek points within a plot of the larger sample would be most likely to capture temporal variability.

An example of how the dispersion calculations were performed is shown in Figure 3. The dispersion of the Nipper Creek assemblage in these plots was calculated by first finding the means of the two principal component scores of all five points. The straight-line distance of each point from the mean was then calculated. These distances were averaged to calculate a measure of the dispersion of the points.

The results of the dispersion calculations (Table 4) show that the Nipper Creek assemblage is *more* dispersed (on average) than the Larry Strong assemblage when principal component 1 is involved in the plots but *less* dispersed when principal component 1 is not involved (Figure 4). The points in the Nipper Creek cache are the least dispersed relative to the Larry Strong Collection when principal components 4 and 5 are used. This observation is consistent with the idea that the morphology of the lateral haft edges may be a dimension of shape variability that is more sensitive to time than basal edge morphology and the and overall proportions of haft regions.

When the entire sample is plotted using principal components 4 and 5, the points from the Nipper Creek cache are confined to a relatively small portion of the distribution (Figure 5). The silhouettes of several of the points in the Larry Strong Collection (scaled to neck width) are provided to illustrate how shape is distributed across the plot. The continuum of haft flare captured by principal component 4 is visible along the x axis, with deeply notched points with widely flaring haft regions present on the left and less flared points on the right. On the y axis (principal component 5), points at the bottom of the plot tend to have rounded ears while points at the top tend to have sharper lateral/basal junctions. The points at the lower left of the plot are the most Taylor-like points in the sample, while some of those at the right edge are approaching an expanding stem configuration. Between these two extremes fall a variety of corner-notched Kirks with a wide range of ear and basal edge shapes.

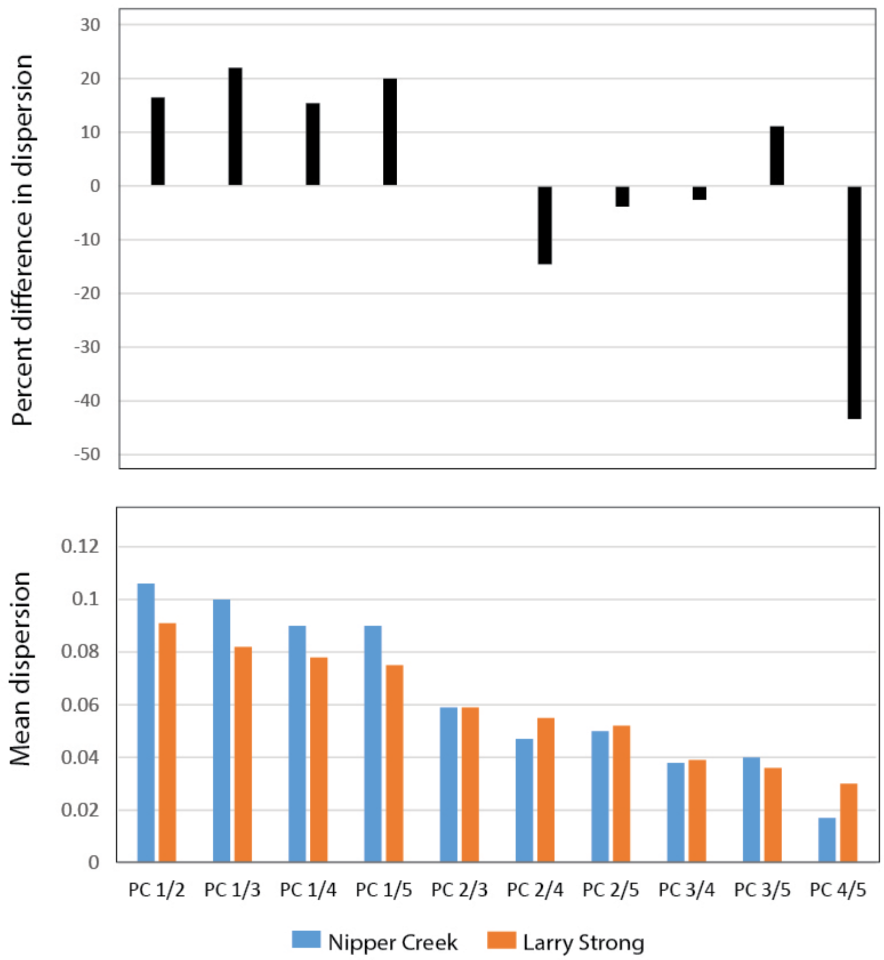


Figure 4. Comparison of mean dispersion of Larry Strong and Nipper Creek assemblages using every possible combination of principal components (bottom); percent difference in dispersion for each pairing, calculated as (Nipper Creek – Larry Strong)/Nipper Creek (top).

Discussion and Conclusion

While the plot shown in Figure 5 obviously does not capture "time" in any simple way, it does suggest several noteworthy aspects of haft variability among Kirk points from this region that may be related to time and thus provide a useful starting point for future analyses.

First, the comparison of patterns of variability in a "short time" assemblage (Nipper Creek) with a "long time" assemblage (Larry Strong) suggests that changes in the lateral edges of the haft (i.e., the degree of flare and shape of the lateral/basal junction) are potentially significant in terms of time. The Nipper Creek assemblage is fairly consistent in these attributes, which is what one would expect if design of the lateral haft margins was strongly influenced by some kind of cultural-bound choice (i.e, if lateral haft morphology is essentially isochrestic). Because we don't know if the Nipper Creek assemblage was created by a single individual, however, we have no way of knowing if the

Table 4. Dispersion of the Nipper Creek and Larry Strong portions of the sample using each possible combination of principal components.

	PC 1	PC 2	PC 3	PC 4
PC 2	Nipper Creek: 0.106 Larry Strong: 0.091			
PC 3	Nipper Creek: 0.100 Larry Strong: 0.082	Nipper Creek: 0.059 Larry Strong: 0.059		
PC 4	Nipper Creek: 0.090 Larry Strong: 0.078	Nipper Creek: 0.047 Larry Strong: 0.055	Nipper Creek: 0.038 Larry Strong: 0.039	
PC 5	Nipper Creek: 0.090 Larry Strong: 0.075	Nipper Creek: 0.050 Larry Strong: 0.052	Nipper Creek: 0.040 Larry Strong: 0.036	Nipper Creek: 0.017 Larry Strong: 0.030

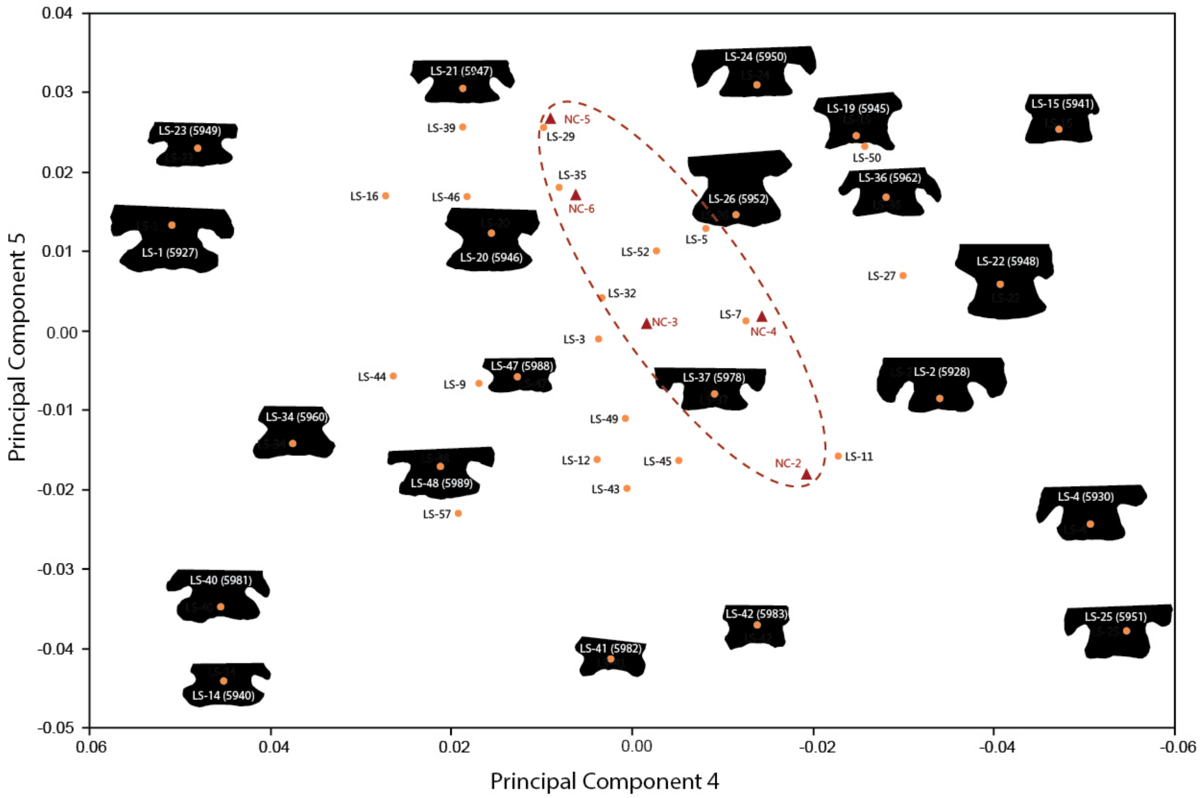


Figure 5. Sample plotted using principal components 4 and 5, with selected silhouettes superimposed to illustrate variability in haft shape; Nipper Creek points are represented by red triangles.

regularity in the lateral haft margins can be attributed to a cultural convention or simply an individual choice.

Choices about basal edge morphology and overall haft proportions did not seem to be as regularized as choices about lateral haft shape in the Nipper Creek points (this is plain to see in the photo provided by Goodyear et al. 2004). Other "short time" Kirk assemblages also appear to encompass a larger degree of variability in the morphology of the basal edge than one would expect if those design choices were highly time-sensitive. The Kirk assemblage from the G. S. Lewis-East site, for example, contains points with straight, convex, and concave basal edges (see Sassaman et al. 2002:Figure 3-2). It is possible that basal edge shape was modified during the use-lives of these points: edges damaged during use would have been repaired by minor chipping and grinding, potentially transforming a convex or straight basal edge into a concave one. An association between the presence/degree of basal concavity and other indicators of use (such as blade attrition) is a testable proposition (Albert Goodyear, personal communication 2016).

The observation that basal edge morphology varies considerably, even in the "short time" assemblage from Nipper Creek, is potentially important, as basal edge shape and treatment are often thought to be a good attributes upon which to base "type" distinctions that are presumed to have temporal significance. While basal edge morphology appears to be account for the greatest amount of variability in the shape analysis performed here, it may not be strongly linked to style *within* the Kirk Corner-Notched cluster (and may, in fact, be linked to function through haft repair and maintenance). It will be important to sort this out going forward to avoid inclusion of non-stylistic variability in a stylistic analysis.

This analysis is intended as a starting point. It could be augmented and expanded significantly in five ways:

(1) Incorporating more "short time" assemblages that provide windows into Kirk variability during relatively brief periods of time;

(2) Including point forms that immediately pre- and post-date Kirk;

(3) Increasing the size of the regional Kirk sample;

(4) Including comparative data from other regions; and

(5) Constructing and testing specific hypotheses about variability in lateral and basal edge morphology.

Addressing the question of patterns of change through time in Kirk would be greatly enhanced by the inclusion of more "short time" assemblages that can be placed within the continuum of Kirk variability. Such assemblages could include groups of points from excavated contexts with some control over time and, potentially, additional caches similar to the one from Nipper Creek. Single points from secure, radiocarbon-dated contexts could also serve as valuable data points.

Including points that pre- and post-date Kirk would help to evaluate to what degree the plot shown in Figure 5 has captured some aspects of change through time. The Larry Strong Collection contains numerous Taylor points (see Bridgman Sweeney 2013), which are thought to immediately pre-date Kirk. Although bifurcate/lobed points are largely absent from the Larry Strong Collection, Stanly points and points that fall within the range of Kirk Stemmed and Kirk Serrated are present. Based simply on haft morphology, Stanly could be a good candidate for a technological/stylistic descendant of Kirk (cf. Coe 1964:122), though most researchers place it after lobed/bifurcate forms in time.

This analysis utilized less than the half of the Kirk points with intact haft regions from the Larry Strong Collection. Laser scanning and processing of the remainder is underway. Repeating the analysis with a larger sample will allow evaluation of the results discussed here and potentially allow ideas about the range and structure of variation in the lateral and basal haft edges to be refined.

Analysis of collections from other regions, both independently and combined with the South Carolina sample, would be useful for evaluating to what degree the range and patterns of variability observed in the Larry Strong points are present elsewhere and to begin assessing how patterns of variability in Kirk are structured with regard to space. Sites with large excavated assemblages in the Great Lakes, Ohio Valley, and Southeast (e.g., Broyles 1971; Chapman 1975; Coe 1964; Collins 1979; Daniel 1998; Ellis et al. 1991; Smith 1995) are good candidates for analysis, as are large surface collections.

Comparisons with other collections could be made using either 3D or 2D data; although the data utilized here were drawn from 3D models, they are essentially 2D and were analyzed as such. Two-dimensional data can be extracted from photographs and drawings, making large-scale analysis possible without the steps and time involved in capturing and processing 3D data.

The basic suggestion of this preliminary analysis is that variation in lateral haft edge morphology is, in general, more closely linked to time than basal edge morphology. This idea can be translated into formal hypotheses and tested in a number of ways using collections varying in temporal span and geographic scale. Analysis need not be limited to the kind of morphometric study presented here: there are numerous other ways to characterize, quantify, and compare aspects of shape. The digital 3D models that were used in this analysis will be freely available for anyone to use.

It is through a formal process of constructing and testing hypotheses that we can begin to understand how different aspects of variability in Kirk are patterned with regard to time and space. A good understanding of those patterns is a fundamental step toward building a robust framework for interpreting the patterns in terms of the people that made the points and the characteristics of the societies those people lived in.

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